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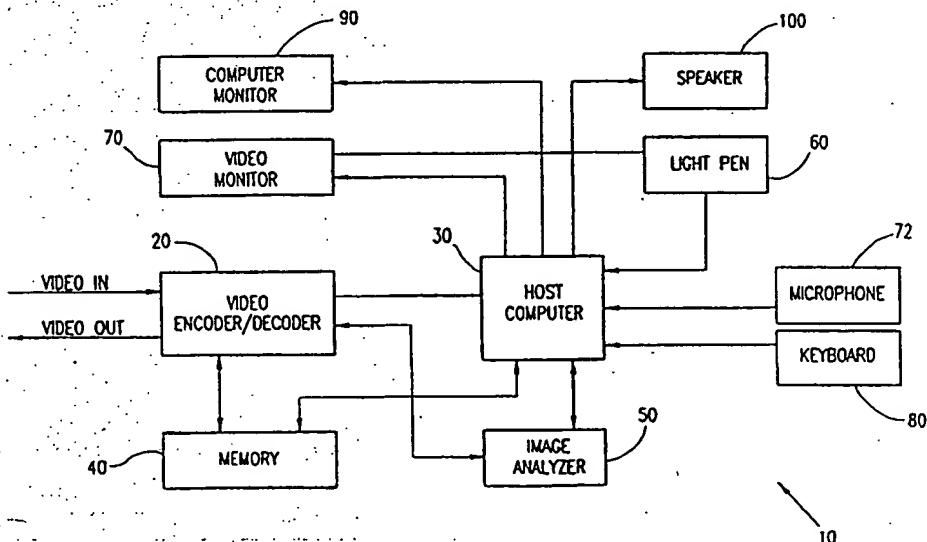
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(54) Title: SPORTS EVENT VIDEO



(57) Abstract

A sports event video manipulating system (10) for manipulating a representation of a sports event, the sports editor including a video field grabber (40) operative to grab at least one video field including a video image, an A/D converter (20) operative to digitize a grabbed video field, an object tracker (30, 50) operative to track an object through a plurality of successive video fields, an object highlighter (30, 50) receiving input from the object tracker (30, 50) and operative to highlight the tracked object on each of the plurality of successive video fields, a D/A image converter (20) operative to convert output of the object highlighter (30, 50) into a video standard format, and a video display monitor (70).

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SPORTS EVENT VIDEO

FIELD OF THE INVENTION

The present invention relates to editing and processing of video segments.

BACKGROUND OF THE INVENTION

12 Documentation of team games such as basketball,
13 football and soccer on video is useful for coaches and
14 players who view the video film in order to understand
15 their own and opponents' past performance. Sports com-
16 mentators also view and show video representations of
17 team games in the course of analyzing these games for
18 their viewers. For this purpose, commercially available
19 analog video editors are currently employed, such as
20 Sports-Tech Video Editor (STVE) of Sports-Tech. Inc. of
21 Fort Lauderdale, Florida.

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28 The present invention seeks to provide a digi-
29 tal sports event video manipulating system which allows a
30 user to manipulate a video representation of a sport
31 event by deriving digital information regarding the
32 sports event from the video representation and manipulat-
33 ing the digital information.

34 There is thus provided in accordance with a
35 preferred embodiment of the present invention a sports
36 event video manipulating system for manipulating a repre-

1 presentation of a sports event, the sports editor including
2 a video field grabber operative to grab at least one
3 video field including a video image A/D converter opera-
4 tive to digitize a grabbed video field, an object tracker
5 operative to track an object through a plurality of
6 successive video fields, an object highlighter receiving
7 input from the object tracker and operative to highlight
8 the tracked object on each of the plurality of successive
9 video fields, a D/A image converter operative to convert
10 output of the object highlighter into a video standard
11 format, and a video display monitor.

12 Further in accordance with a preferred embodiment
13 of the present invention, the video field grabber
14 is replaced by a video frame grabber.

15 Still further in accordance with a preferred
16 embodiment of the present invention, the system also
17 includes a marking device allowing a user to indicate an
18 object of interest and providing an output indication of
19 the object of interest to the object tracker.

20 Still further in accordance with a preferred
21 embodiment of the present invention, the system includes
22 a video editor operatively associated with the video
23 field grabber and with the video display monitor.

24 Additionally in accordance with a preferred
25 embodiment of the present invention, the object tracker
26 includes an object exiting monitor operative to monitor
27 for exit of an object from at least one video field.

28 Further in accordance with a preferred embodiment
29 of the present invention, the object tracker is
30 operative to track a plurality of objects.

31 Still further in accordance with a preferred
32 embodiment of the present invention, the object tracker
33 includes an occlusion predictor operative to predict
34 occlusion of at least one of the plurality of tracked
35 objects by at least one other object.

36 Additionally in accordance with a preferred

1 embodiment of the present invention, the object tracker
2 includes a moving object identifier operative to identify
3 objects which are in motion at least some of the time as
4 the plurality of objects to be tracked.

5 Still further in accordance with a preferred
6 embodiment of the present invention, the moving object
7 identifier includes a color analyzer operative to distin-
8 guish at least one color characterizing objects at least
9 sometimes in motion from at least one background color
10 characterizing stationary objects.

11 Additionally in accordance with a preferred
12 embodiment of the present invention, the object tracker
13 includes actual location computation means operative to
14 compute and store an indication of an actual location of
15 a tracked object at an individual time.

16 Further in accordance with a preferred embodi-
17 ment of the present invention, the object tracker in-
18 cludes field-of-view direction determining means opera-
19 tive to provide an indication of the actual direction of
20 a current field of view center.

21 There is also provided, in accordance with
22 another preferred embodiment of the present invention, a
23 video imagery manipulating system for manipulating video
24 imagery including a video field grabber operative to grab
25 at least one video field, an object tracker operative to
26 track an object through a plurality of successive video
27 fields, and an object highlighter receiving input from
28 the object tracker and operative to highlight the tracked
29 object on each of the plurality of successive video
30 fields.

31 There is also provided, in accordance with
32 another preferred embodiment of the present invention, a
33 sports event video manipulating system for manipulating a
34 representation of a sports event, the sports editor
35 including video field grabber operative to grab at least
36 one video field including a video image A/D converter

1 operative to digitize a grabbed video field, and field
2 mosaic composer operative to receive a plurality of
3 digitized fields from the video field grabber, represent-
4 ing a corresponding plurality of small portions of an
5 arena and to compose a mosaic of fields representing a
6 larger portion of the arena.

7 Further in accordance with a preferred embodi-
8 ment of the present invention, the system also includes
9 a field mosaic graphic output system operative to pro-
10 vide a visually sensible representation of the larger
11 portion of the arena.

12 Still further in accordance with a preferred
13 embodiment of the present invention, the field mosaic
14 graphic output system includes a video display, and a D/A
15 converter operative to convert a digital representation
16 of the field mosaic to a video representation thereof.

17 Additionally in accordance with a preferred
18 embodiment of the present invention, the field mosaic
19 graphic output system includes a computer screen.

20 Further in accordance with a preferred embodi-
21 ment of the present invention, the field mosaic graphic
22 output system includes a printer.

23 Still further in accordance with a preferred
24 embodiment of the present invention, the video field
25 grabber includes a video frame grabber operative to grab
26 at least one video frame and wherein the A/D converter is
27 operative to digitize a grabbed video frame and wherein
28 the field mosaic composer includes a frame mosaic compos-
29 er operative to receive a plurality of digitized frames
30 from the video frame grabber and to compose therefrom a
31 mosaic of frames.

32 Still further in accordance with a preferred
33 embodiment of the present invention, the plurality of
34 small portions are viewed from a corresponding plurality
35 of distances, the differences between at least some of
36 the distances being comparable in size to the distances

1 themselves.

2 Further in accordance with a preferred embodiment
3 of the present invention, the plurality of small
4 portions are viewed from a single location.

5 There is also provided, in accordance with
6 another preferred embodiment of the present invention, a
7 sports event video manipulating system for manipulating a
8 representation of a sports event, the sports editor
9 including a video field grabber operative to grab a video
10 field sequence including a video image A/D converter
11 operative to digitize a grabbed video field, and a
12 motion-based foreground-background discriminator opera-
13 tive to differentiate foreground objects in the video
14 field sequence from background in the video field se-
15 quence, at least partly on the basis of foreground object
16 motion.

17 Further in accordance with a preferred embodiment
18 of the present invention, the system includes a
19 field mosaic composer operative to receive a sequence of
20 pluralities of digitized fields from the video field
21 grabber, each plurality of digitized fields representing
22 a corresponding plurality of small portions of an arena
23 and to compose a sequence of mosaics of fields, each
24 mosaic representing a larger portion of the arena and the
25 discriminator is operative to differentiate foreground
26 objects in the sequence of mosaics.

27 There is also provided, in accordance with a
28 further preferred embodiment of the present invention, a
29 sports event video manipulating system for manipulating a
30 representation of a sports event, the sports editor
31 including a video field grabber operative to grab at
32 least one video field including a video image A/D con-
33 verter operative to digitize a grabbed video field, and
34 a foreground object shape foreground-background discrimi-
35 nator operative to differentiate foreground objects in
36 the video field from background in the video field, at

1 least partly on the basis of foreground object shape.

2 There is additionally provided, in accordance
3 with another preferred embodiment of the present inven-
4 tion, a sports event video manipulating system for
5 manipulating a representation of a sports event, the
6 sports editor including a video field grabber operative
7 to grab at least one video field including a video image
8 A/D converter operative to digitize a grabbed video
9 field, and a foreground object shape foreground-back-
10 ground discriminator operative to differentiate a charac-
11 ter-bearing foreground object in the video field from
12 background in the video field, at least partly on the
13 basis of character recognition.

14 Further in accordance with a preferred embodi-
15 ment of the present invention, the discriminator differ-
16 entiates foreground objects from background objects at
17 least partly on the basis of color.

18 Still further in accordance with a preferred
19 embodiment of the present invention, the system includes
20 a foreground object eliminator operative to eliminate
21 foreground objects and replace them with adjacent back-
22 ground information.

23 Further in accordance with a preferred embodi-
24 ment of the present invention, the system also includes a
25 selected object replacer operative to identify a selected
26 object and to replace the selected object with an icon in
27 the mosaic.

28 Still further in accordance with a preferred
29 embodiment of the present invention, the video indexing
30 method includes the steps of providing a digital repre-
31 sentation of a video sequence featuring at least one
32 object performing at least one type of action, and index-
33 ing the video sequence according to at least one index.

34 Further in accordance with a preferred embodi-
35 ment of the present invention, the step of indexing
36 includes the step of indexing according to the identity

1 of the object.

2 Still further in accordance with a preferred
3 embodiment of the present invention, the step of indexing
4 includes the step of indexing by action type.

5 Additionally in accordance with a preferred
6 embodiment of the present invention, the video sequence
7 represents a sports event and the step of indexing ac-
8 cording to the identity of the object includes the step
9 of indexing according to the identity of at least one
10 player participating in at least a portion of the sports
11 event.

12 Still further in accordance with a preferred
13 embodiment of the present invention, the step of indexing
14 includes the step of indexing according to the identity
15 of a team participating in the sports event.

16 Additionally in accordance with a preferred
17 embodiment of the present invention, the step of indexing
18 includes the step of indexing according to the following
19 group of action types: offense, and defense.

20 Further in accordance with a preferred embodi-
21 ment of the present invention, the step of indexing
22 includes the steps of receiving at least one audio signal
23 corresponding to at least one frame of the video se-
24 quence, and keyword spotting the audio signal for indices
25 in order to index the video sequence in accordance with
26 detected indices.

27 Further in accordance with a preferred embodi-
28 ment of the present invention, the step of receiving
29 includes the step of receiving the audio channel of the
30 video sequence.

31 Still further in accordance with a preferred
32 embodiment of the present invention, the step of receiv-
33 ing includes the step of receiving an audio message from
34 a user indicating an index.

35 Additionally in accordance with a preferred
36 embodiment of the present invention, the foreground

1 object shape discriminator includes a ball recognizer
2 operative to recognize a ball.

3 Further in accordance with a preferred embodiment
4 of the present invention, the discriminator includes
5 a team uniform recognizer operative to recognize member
6 of a sports team by at least one characteristic of his
7 uniform.

8 There is also provided, in accordance with
9 another preferred embodiment of the present invention, a
10 television sports event replay method including the steps
11 of receiving a video sequence of at least a portion of a
12 sports event featuring at least one object in action,
13 selecting at least one of the objects in action, tracking
14 the selected objects through the video sequence, and
15 broadcasting a replay of the video sequence on television
16 with the selected objects highlighted.

17 There is also provided, in accordance with
18 another preferred embodiment of the present invention, a
19 television sports event replay method including the steps
20 of receiving a video sequence of a sports event segment,
21 featuring at least one object in action, wherein first
22 and second portions of the segment takes place in first
23 and second portions of the playing field, respectively
24 and the second and first portions are not visible in the
25 video representation of the first and second portions,
26 respectively, of the sports event, and broadcasting on
27 television a representation of the sports event segment
28 in which the first and second portions of the playing
29 field constantly appear.

30 Further in accordance with a preferred embodiment
31 of the present invention, the object highlighter is
32 operative to draw the past trajectory of at least one
33 tracked object.

34 There is also provided, in accordance with
35 another preferred embodiment of the present invention, a
36 sports event video manipulating method for manipulating a

1 representation of a sports event, the method including
2 grabbing and digitizing at least one video field, track-
3 ing an object through a plurality of successive video
4 fields, receiving input from the object tracker and
5 highlighting the tracked object on each of the plurality
6 of successive video fields, and converting output of the
7 object highlighter into a video standard format.

8 There is also provided, in accordance with
9 another preferred embodiment of the present invention, a
10 video imagery manipulating method for manipulating video
11 imagery including grabbing at least one video field,
12 tracking an object through a plurality of successive
13 video fields, and receiving input from the object track-
14 er and highlighting the tracked object on each of the
15 plurality of successive video fields.

16 There is also provided, in accordance with
17 another preferred embodiment of the present invention, a
18 sports event video manipulating method for manipulating a
19 representation of a sports event, the method including
20 grabbing and digitizing at least one video field, and
21 receiving a plurality of digitized fields from the video
22 field grabber, representing a corresponding plurality of
23 small portions of an arena and composing a mosaic of
24 fields representing a larger portion of the arena.

25 There is also provided, in accordance with
26 another preferred embodiment of the present invention, a
27 sports event video manipulating method for manipulating a
28 representation of a sports event, the method including
29 grabbing and digitizing a video field sequence, and
30 differentiating foreground objects in the video field
31 sequence from background in the video field sequence, at
32 least partly on the basis of foreground object motion.

33 There is also provided, in accordance with
34 another preferred embodiment of the present invention, a
35 sports event video manipulating method for manipulating a
36 representation of a sports event, the method including

1 grabbing and digitizing at least one video field, and
2 differentiating foreground objects in the video field
3 from background in the video field, at least partly on
4 the basis of foreground object shape.

5 There is also provided, in accordance with
6 another preferred embodiment of the present invention, a
7 sports event video manipulating method for manipulating a
8 representation of a sports event, the method including
9 grabbing and digitizing at least one video field, and
10 differentiating a character-bearing foreground object in
11 the video field from background in the video field, at
12 least partly on the basis of character recognition.

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1 BRIEF DESCRIPTION OF THE DRAWINGS
23 The present invention will be understood and
4 appreciated from the following detailed description,
5 taken in conjunction with the drawings in which:6 Fig. 1 is a simplified block diagram of a
7 sports event analysis system which is constructed and
8 operative in accordance with a preferred embodiment of
9 the present invention;10 Fig. 2 is a sample display of a video frame
11 including a highlighted player and an indication of the
12 past trajectory of the highlighted player;13 Figs. 3A and 3B, taken together, form a simpli-
14 fied flowchart of a preferred method for highlighting a
15 video representation of an object included in a video
16 representation of a scene;17 Fig. 4 is a pictorial illustration of conver-
18 sion of a sequence of narrow-field partially overlapping
19 frames into a single image with a wide field of view;20 Figs. 5A and 5B, taken together, form a simpli-
21 fied flow-chart of a preferred method for generating a
22 global diagnostic image; and23 Figs. 6A and 6B are two sample video frames
24 illustrating two options for diagnosis offensive sets in
25 a soccer game.

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1 DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

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3 The role of video to analyze certain team games
4 such as basketball, football and soccer, is rapidly
5 growing. Using video allows both coaches and players to
6 visualize what the players have done right, what they
7 have done wrong and where they must improve. From a
8 coaching standpoint it helps in preparing game strategies
9 against different opponents.

10 In addition to pre-game analysis of opponent
11 scouting tapes and post-game analysis for self improve-
12 ment, there is also need for a fast editing and analysis
13 tool for half-time situations to allow the coaches to
14 make strategy adjustments during halftime.

15 There is also a growing need for sport commen-
16 tator demonstration tools in TV studios. These are needed
17 to educate the viewers, to show them the various strate-
18 gies and typical moves and exercises of the game in order
19 to increase their interest and ultimately to increase the
20 ratings of the program and the station.

21 Advertising messages or sponsorship logos
22 superimposed on such diagnostic screens or clips are very
23 effective since they are usually displayed after an
24 important tactic in the game.

25 Before proceeding with a description of the
26 apparatus depicted in Fig. 1, the following comments are
27 pertinent: The uses of the apparatus and method relate to
28 video editing and include but are not limited to analysis
29 of video clips captured during sports games. The appara-
30 tus of this invention may include, or operate in conjunc-
31 tion with, a general purpose video editing machine.

32 The embodiments described below refer, but are
33 not limited to digital video editing systems and can
34 include, or operate in conjunction with analog video
35 editors as well.

36 Reference is now made to Fig. 1 which illus-

1 trates a sports event analysis system, referenced gener-
2 ally 10, including a video encoding/decoding unit 20, a
3 host computer 30, a digital memory storing device 40, an
4 image analyzer 50, an annotation aid such as a lightpen
5 60 and a video monitor 70.

6 The system 10 is operative to perform editing,
7 analysis and diagnostic representations of video segments
8 of sports events. The video encoder/decoder unit 20,
9 such as an Optibase JPEG-2000, is operative to grab and
10 digitize a sequence of individual frames from the color
11 video input, preferably in real - time (25 or 30 frames
12 per second), and to convert a digital image back into
13 analog video.

14 This unit is preferably able to compress and
15 decompress the video images so that longer video segments
16 may be stored in the digital memory 40. The Optibase JPG-
17 2000 board is using Motion JPEG algorithm for compres-
18 sion; other algorithms, such as MPEG, may also be used.

19 The video encoder/decoder receives the video
20 input from a plurality of optional sources such as a
21 Video Cassette player (VC), a Video Disk player (VD) or
22 broadcasted transmission and also outputs live video. The
23 frame grabber can grab and digitize a full frame or
24 preferably, due to camera scanning and players movements,
25 to operate on single fields.

26 Host computer 30 may comprise a pc 486DX-50
27 with 8 MB RAM. The host computer preferably includes an
28 audio board, installed into one of the extension slots,
29 that can store and synchronize at least one audio channel
30 and may also include a user dependent or user independent
31 key-word spotting unit. The computer preferably communi-
32 cates with the following units:

33 a. video monitor 70 which may comprise a JVC 21"
34 RGB/YC/PAL;
35 b. an edit monitor 90 such as a SVGA 14" non-interlaced
36 low radiation monitor;

1 c. one or more user input devices which may, for example,
2 include light pen 60, microphone 72 and a keyboard 80;
3 d. one or more user output devices which may, for exam-
4 ple, include stereo speakers 100;
5 e. digital memory storage device 40 which may comprise 2
6 GigaBytes SCSI Hard Disk; and
7 f. image analysis, tracking and registration unit 50,
8 also termed herein "image analyzer 50", which is opera-
9 tive to analyze and manipulate a sequence of digital
10 images and to create diagnostic or processed output that
11 can be displayed on the video monitor 70 and/or sent into
12 the output video port.

13 The image analyzer 50 preferably comprises at
14 least one dedicated electronic board that is installed in
15 the host computer extension slots and communicates with
16 its bus. The image analyzer 50 operates on the spread
17 image or rather makes use of the compressed data associ-
18 ated with the spread image.

19 The system of Fig. 1 is preferably operative to
20 perform a plurality of types of analysis, manipulation
21 and editing operations on a video representation of a
22 sports event, such as but not limited to the following
23 operations:

24 a. Control of the video input device - the VD or
25 VC input is remotely controlled from the computer screen.
26 The operator may use a plurality of control functions
27 such as: fast forward, fast search backwards, play (no
28 compression), record 20 (go back 20 seconds, compress and
29 store on disk), stop.

30 b. Indexing video segments - the operator can
31 quickly mark start and end points of relevant video
32 segments in PLAY mode. This is preferably done using
33 means such as a light pen, touch screen or a trackball.
34 It may also be implemented using the audio channel - the
35 operator says key-words describing the video segment into
36 the microphone and the system later uses an audio key-

1 word spotting unit (for example, a user dependent speech
2 recognition pc board) to locate the clip in the synchro-
3 nized audio channel.

4 The segments are indexed according to any
5 suitable criteria, preferably user-selected criteria,
6 such as but not limited to type of offensive exercise,
7 defense type, identified player habits, and then logged
8 into the memory. All segments having the same index can
9 later be accumulated for editing, analysis and sorting
10 out.

11 c. On-line graphical blending and audio dubbing -
12 when recording a video segment into system memory the
13 operator can add graphical overlays on the video for
14 example by directly "writing" on the screen with a light
15 pen or by adding a vocal description using the micro-
16 phone.

17 d. Editing and sorting indexed video segments -
18 the operator may perform a plurality of editing opera-
19 tions on each indexed segment such as but not limited to
20 changing start/stop points, deleting clips and adding
21 graphical overlays or animation clips. He may then create
22 groups of segments to be later recorded on video cas-
23 settes and distributed among the players.

24 e. Spotting key-words on the original audio chan-
25 nel of the video input such as players' names, to auto-
26 matically accumulate the video segments associated with
27 these players. This preferably utilizes a key-word
28 spotting system; a speaker dependent key-word spotter
29 demands a training phase before running each cassette.

30 f. Automatic tracking and highlighting of objects
31 selected on a first frame of a segment throughout the
32 sequence of frames composing an event until the objects
33 get out of the camera field of view as illustrated by way
34 of example in Fig. 2. A past trajectory of the objects
35 may be superimposed on the video as also depicted in Fig.
36 2.

1 g. Creation of a wide field of view (FOV) background image of the playing fields by mosaicking partially overlapping narrow FOV consecutive frames, automatic placing of players and production of analysis video segments "played" on the global playing fields image as shown in Fig. 4. These video clips may later be edited and sorted as all others.

8 A preferred method of employing the system of Fig. 1 to perform operation f is as follows:

10 Each frame of the input video stream is grabbed, digitized and preferably compressed by the video encoder/decoder unit 20. Objects are marked on the first frame of the video stream by the system operator preferably by using the light pen 60. The digital frame information is typically stored in memory 40 and can be accessed and spread by the decoder 20. The frame pixels data is then DMAed by means of a fast video bus into the image analyzer 50 that uses a real-time motion estimation chip such as SGS-THOMSON STI3220 and a dedicated circuit to estimate the motion and to track the marked objects of interest and to estimate the motion of background windows at video rate.

23 A graphical object enhancement overlay is then created and stored on the hard disk memory 40. When the operator wishes to record the sequence on a VCR the frames are decoded in unit 20 and the corresponding graphical overlays are superimposed on each frame. The composed image is then analog converted and sent to the video output port.

30 A preferred method of employing the system of Fig. 1 to perform operation g is similar to that described for operation f except that the image analyzer 50 is now used to perform registration of the current frame into the previous ones and to generate the global diagnostic still image or video clip. The light pen 60 is used here also to manually "paint" the residual "holes"

1 in the background global image in addition to marking
2 objects of interest in the first frame of the replayed
3 set.

4 Fig. 2 is a sample display of a video frame
5 including a highlighted player and an indication of the
6 past trajectory of the highlighted player.

7 Reference is now made to Figs. 3A and 3B which,
8 taken together, form a simplified flowchart of a pre-
9 ferred method for highlighting a video representation of
10 an object included in a sequence of video representa-
11 tions of an event, such as a sport event, which may be
12 performed by units 30 and 50 of Fig. 1.

13 In step 100 the video encoder 20 grabs and
14 digitizes the first video frame.

15 In step 110, the system accepts a user's indi-
16 cation of at least one object to be highlighted. For
17 example, the user may indicate an object by touching its
18 image on the first video frame of the sequence with light
19 pen 60 of Fig. 1.

20 In step 120, the video analyzer 50 of Fig. 1
21 detects and identifies the boundaries of the selected
22 objects, using a conventional edge detection method. For
23 example, Gaussian edge detection, as described in the
24 following publication, has been found to be suitable:

25 J.F.Canny, "A computational approach to
26 edge detection", IEEE Trans. Pattern Analysis and Machine
27 Intelligence, vol. 8, pp. 679-698, November 1986.

28 The disclosure of the above-referenced publica-
29 tion and of all publications cited therewithin is hereby
30 incorporated by reference.

31 Alternatively, however, other conventional edge
32 detection methods may be employed such as those described
33 in the following references:

34 F.M. Dickley and K.M. Shanmugan, "An
35 optimal frequency domain filter for edge detection in
36 digital pictures", IEEE Transactions on Pattern Analysis

1 and Machine Intelligence, PAMI-1(1):37-49, 1977.

2 R.M. Haralick, "Digital step edge from
3 zero-crossings of second directional derivatives", IEEE
4 Transactions on Pattern Analysis and Machine Intelli-
5 gence, PAMI-6(1):58-68, 1984.

6 D. Marr and H. Hildreth, "Theory of edge
7 detection", Proceedings of the Royal Society of London,
8 B(207):187-217, 1980.

9 The disclosures of the above-referenced publi-
10 cations and of all publications cited therewithin are
11 hereby incorporated by reference.

12 A problem that has been encountered and identi-
13 fied as a possible obstacle to the edge detection task is
14 image degradation due to motion induced blur. This may be
15 due either to camera scanning or to object motion. The
16 motion blur identification technique such as the ones
17 described in the following reference may be used as part
18 of step 120 in Fig. 3A:

19 R.C. Gonzalez and P. Wintz, "Digital
20 image processing", Addison-Wesley, 1977.

21 In step 122 all edge pixels with an edge
22 strength below a user-specified threshold are ignored.
23 All those above are marked as candidate boundary pixels.
24 Connected sequences of candidate boundary pixels
25 ("strings") are then identified. A connected sequence is
26 defined as the set of boundary pixels such that a path
27 consisting solely of boundary pixels exists between any
28 two pixels in the set. Strings which are very close to
29 one another are connected. At this point, just one con-
30 nected string normally exists for each marked object
31 which is guaranteed to completely surround a "central
32 region" of the object.

33 In step 124, objects whose connected strip of
34 edges was detected and defined in steps 120 and 122 are
35 highlighted in the initial frame viewed by the user in
36 the course of performing step 110.

1 In step 140, a frame index n is initialized to
2 2, since forthcoming steps 150-230 are performed for each
3 video frame from the second frame, i.e. the frame follow-
4 ing the initial frame which the user employed in perform-
5 ing step 110, onward.

6 In step 146, the video encoder 20 grabs and
7 digitizes the n'th frame.

8 In step 150, a tracking technique is employed
9 to detect, in frame n, the objects marked in step 110.
10 The boundaries of the marked objects detected on the
11 first video frame of the session, or in the previous
12 frame, are used to track the object throughout the
13 succession of frames using the method of edge tracking.
14 This is done by defining a dynamical search window cen-
15 tered around the object location in the previous frame
16 and performing the edge detection procedure inside this
17 window.

18 From the third frame on, the direction of the
19 relative motion of the object may be predicted and the
20 search window may then be centered on the predicted
21 point. The first step in edge tracking applies one of the
22 known edge detection algorithms mentioned above.

23 The next steps are thresholding and continuity
24 processes, as described above. Alternatively, the above
25 tracking method may be replaced by the following method:
26 when the object is large enough to embody well defined
27 correlation windows or features, the tracking may be
28 executed by correlating such windows, taken from subse-
29 quent frames.

30 For objects typically characterized by a bound-
31 ing rectangle larger than 10x10 pixels, reliable feature
32 detection is expected and the correlation tracking method
33 usually has a better probability of success than the edge
34 tracking technique. A combination of these tracking proce-
35 dures and others may also be used. The tracking proce-
36 dure takes into account the fact that there may be a

1 change of magnification (zoom in and out) and of objects'
2 poses through the succession of frames.

3 In step 160, the system analyses and detects
4 the following situations:
5 "fusion" - two or more objects which have merged into
6 one;

7 "splitting" - one "fused" object which has split into at
8 least two separated objects;
9 occlusion - an object which is partially blocked by
10 another object (player, referee or by the ball).

11 Two approaches may be implemented to identify
12 these phenomena:

13 a. The internal region of a marked object is matched, by
14 means of a pixel correlation method, to the same region
15 in the previous frame. When a large local mismatch is
16 identified it may be due to occlusion or fusion. The
17 pixel correlation image should first be smoothed to
18 cancel noise.

19 b. All moving objects in the scene (players, referees and
20 the ball) are continuously detected and tracked from
21 frame to frame. If occlusion of a marked object, by one
22 of the players or by the ball, occurs, fusion and split-
23 ting may then be predicted. A method for distinguishing
24 between a uniformly moving background and foreground
25 objects moving in different velocities is described below
26 with reference to steps 350-370 of Fig. 5A.

27 In step 170, the system, after detection and
28 localization of all tracked objects, executes a "disap-
29 pearance analysis" to monitor all objects that have
30 exited the camera field of view and those that are pre-
31 dicted, according to their computed angular speed, to
32 exit the field of view in the forthcoming frames.

33 Along with the exiting monitoring, a reentry
34 analysis is performed to identify those marked and previ-
35 ously-tracked objects that have disappeared but have
36 reentered the scene (i.e., the camera field of view) in

1 the current frame.

2 The probability of success of the reentry
3 analysis is lower than the probability of success of
4 disappearance analysis.

5 The method used for the reentry analysis pref-
6 erably includes the following steps:

7 1) keeping an inventory of the global coordinates of
8 exiting objects at the moment of their exit. The computa-
9 tion of the global coordinates of a given pixel of frame
10 n is described with reference to steps 340-380 of Fig.
11 5A.

12 2) prediction of the location of the objects in
13 global coordinates based on their last computed velocity
14 vector.

15 3) conversion of the predicted object location from
16 the global coordinates into reentry frame coordinates.

17 In step 180, the program decides, according to
18 a pre-defined criterion, if the number of marked objects
19 in the field of view is sufficient to continue the proc-
20 ess into the following frames. When the number of objects
21 has decreased below a given threshold it becomes reasona-
22 ble to assume that the set has degenerated into an insig-
23 nificant scene and the program terminates. It is still
24 under the operator's discretion to reactivate the code
25 from the termination point on.

26 Typically, in steps 190 and 200, the boundaries
27 of the tracked objects in frame n are defined. Sometimes
28 these boundaries have already been defined, e.g. in step
29 150, when edge tracking has been used. The edge strength
30 of the boundaries is thresholded according to a pre-
31 defined criterion, connected sequences of candidate
32 boundary pixels are identified, strings which are very
33 close to one another are connected and the main connected
34 string, guaranteed to enclose a central region, is iden-
35 tified.

36 In step 206 the past trajectories of the marked

1 objects on the current frame are computed. This process
2 involves computation of each object's centroid (or any
3 other reference point) in previous frames and conversion
4 into current frame coordinates through the global frame
5 of reference, as explained in step 450 of Fig. 5B.
6 In step 210 the marked objects that have been
7 tracked are highlighted.

8 The term "highlighting" is used herein to refer
9 to any suitable emphasis of an individual object in a
10 display, or of a portion of an individual object, such
11 as, but not limited to, its boundary, as detected and
12 defined in step 200, or to a manipulation of the object
13 or object portion such as color change, shadowing, blink-
14 ing, or adding an emphasizing element such as a framing
15 element surrounding the object, an arrow continuously
16 pointing at the object, a caption appropriate to the
17 object which travels continuously along therewith. Proper
18 measures to prevent edge and texture aliasing are taken
19 when applying any part of these dynamic emphasizing
20 techniques.

21 The previously computed past trajectories of
22 the marked objects may also be superimposed on the video
23 frame in step 210.

24 In step 220, the localization of objects of
25 interest in the global coordinate system, required for
26 the reentry analysis is executed.

27 In step 230 the frame number is advanced and
28 the highlighting process is repeated.

29 A problem usually encountered in the analysis
30 of team games is the difficulty in conceptualizing a
31 whole wide field of view of an offensive or defensive
32 tactic out of the succession of partially overlapping
33 video frames that were captured by at least one TV camera
34 using relatively narrow fields of view centering around
35 the instantaneous location of the ball and active play-
36 ers.

1 The system of the present invention is prefera-
2 bly characterized in that one large pseudo-real image of
3 the playing fields, or a relatively large portion of
4 thereof, is mosaiced from among the successive partially
5 overlapping video frames generated by the camera in the
6 course of the event.

7 The frames are first composed in mosaic fashion
8 to create a global background image onto which the active
9 players and the ball are placed in their accurate loca-
10 tions using their real images or graphical icons, thus
11 demonstrating a comprehensive representation of all the
12 moves composing the event and allowing better understand-
13 ing of the event.

14 Fig. 4 is a pictorial illustration of conver-
15 sion of a sequence of narrow-field partially overlapping
16 frames into a single image with a wide field of view.

17 Reference is now made to Figs. 5A and 5B which,
18 taken together, form a simplified flowchart of a pre-
19 fered method for generating this global diagnostic image
20 which may be performed by the image analyzer 50 and host
21 computer 30 of Fig. 1.

22 In optional step 310, the operator manually
23 selects the objects of interest whose performance he
24 wants to analyze through the replayed set. This is done
25 using an annotation aid such as a light pen or a mouse.
26 When this step is omitted, the system preferably consid-
27 ers all subsequently identified foreground objects in the
28 image as objects of interest.

29 It is also possible that the system will auto-
30 matically classify detected foreground objects according
31 to their colors, identified back numbers of players,
32 geometrical shape (for example, the round shape of a
33 ball) and/or other attributes and will select a subset of
34 foreground objects to be defined as objects of interest.

35 Although the main implementation of this method
36 will be during replay situations, it is possible to

1 employ the method in the real time of the event. In such
2 cases the automatic selection of objects of interest is
3 normally a necessity.

4 In step 320, the first frame or first field is
5 grabbed by the video encoder 20, digitized and, optional-
6 ly, compressed to serve as a seed for the global image.

7 In step 330, a frame index n is initialized to
8 2, since forthcoming steps 340-450 are performed for each
9 video frame from the second frame, i.e. the frame follow-
10 ing the initial frame which the user employed in perform-
11 ing step 310, onward.

12 In step 340, the nth video frame is grabbed,
13 digitized and, optionally, compressed by the unit 20.

14 In step 350, the area of the frame is divided
15 into a large number, typically 100, of separate contigu-
16 ous small window areas. The windows are then classified
17 and each of them is given a weight representing its
18 information content. In step 360, the correla-
19 tion value (or another value such as the sum of absolute
20 differences) of each window of frame n with the corre-
21 sponding window in the (n-1)'th frame for each point
22 inside a given search window, is computed.

23 The matrix of correlation values is then fitted
24 to a 2-d polynomial to achieve the minimum value with
25 sub-pixel accuracy. The vector motion associated with
26 each correlation window is then computed from the meas-
27 ured shift and frame periods.

28 The average value, considered the "majority
29 motion" velocity, is then computed. The deviating windows
30 are excluded and the global motion is remeasured. This
31 process is iteratively continued until convergence is
32 achieved. In each iteration, smaller window sizes may be
33 used to obtain a better spatial resolution.

34 In step 370, the local window shift information
35 is used to distinguish between foreground objects, i.e.
36 moving objects, and background regions in the image which

1 have the "majority motion" velocity that is usually due
2 to camera scanning.

3 In step 380, the identified "background re-
4 gions" of frame n are registered into the (n-1)'th frame.
5 Since this is done successively on all frames composing
6 the event, a "global" wide field of view (FOV) background
7 image is incrementally composed in mosaic fashion from
8 the narrow FOV partially overlapping frames. The warping
9 process is executed using proper averaging since contri-
10 butions to a given pixel in the global image may come
11 from more than one frame due to the large overlap between
12 successive frames.

13 In step 390, the system defines a subset of
14 identified foreground objects in the current frame that
15 are objects of interest selected, either automatically or
16 by the user in the first frame. This is executed using
17 one of the methods of step 150 of Fig. 3.

18 The information pertaining to the identity and
19 locations of the centroids or other reference points,
20 strings or matrices of pixels belonging to these identi-
21 fied objects of interest, are then computed in the local
22 frame and global image coordinate systems. This informa-
23 tion is stored for later use.

24 In step 410, an "end of session" decision is
25 taken by the system. The criterion for such a decision
26 may be a pre-programmed point of time or frame number, a
27 major failure of the windows correlation mechanism,
28 sometimes indicating a "cut" initiated by the TV produc-
29 er, or a situation in which the number of identified
30 objects of interest in the camera FOV has decreased to a
31 value below a pre-programmed threshold. When "end of
32 session" is declared the program stops the flow of video
33 frames and continues with steps 430-460 of Fig. 5B.

34 In step 420, the system advances the frame
35 number by one and repeats steps 340-410 for the new
36 frame.

1 In step 430, the system performs an automatic
2 "hole filling" process on the global image mosaic. As
3 described above, each pixel in each frame is classified
4 as a background or foreground pixel. If it is a back-
5 ground pixel, it is used to update the corresponding
6 pixel of the global image when added with the proper
7 weighting. If the pixel is classified as a "foreground
8 pixel", its value is ignored. The probability that a
9 given background pixel of the global image will be oc-
10 cluded with foreground objects through the whole succes-
11 sion of overlapping frames is typically low but non-zero,
12 and the existence of consequent "holes" in the global
13 image cannot, therefore, be ruled out.

14 In step 430 these holes are automatically
15 "filled" using spatial averages of neighboring pixel
16 values.

17 In step 440, the user optionally paints any
18 residual holes which may remain after the execution of
19 automatic hole painting step 430.

20 This may be effected using annotation aid 60
21 and standard graphics software. At this point, the user
22 may also "eliminate" residual foreground objects that
23 have not been discriminated by the automatic process,
24 such as stationary players. In step 450, the
25 system registers the identified objects of interest,
26 whose global coordinates have been computed for each
27 frame in step 390, on the global background image at
28 various time points. The system may automatically display
29 all the objects or enable the operator to select only a
30 few objects to be displayed on the diagnostic screen.

31 In step 460, the system displays the diagnostic
32 image or video clip on the video monitor 70, the computer
33 monitor 90, and/or sorts it into the video output port of
34 unit 20 for recording or transmission. At least the
35 following display options of the diagnosis information
36 are preferably provided:

1 a. Icons of the objects of interest, typically including
2 players and a ball, are superimposed on the global
3 background image at each selected point of time and the
4 temporal evolution of the set is displayed in a film-like
5 manner.

6 b. The images of the objects of interest themselves are
7 superimposed and the time evolution is displayed as a
8 video clip resembling the original video output except
9 for the two following differences:

10 1. the background is a wide angle view embodying
11 a substantial portion of the playing fields thereby to
12 orient a spectator in the field and to afford the specta-
13 tor a better understanding of the tactical moves.

14 2. players that did not take part in the set are
15 "eliminated" so that the spectators' attention is focused
16 on the active players.

17 c. Trajectories of players and/or ball may also be auto-
18 matically displayed with optional time marking points.

19 d. Still images summarizing the entire event by superim-
20 posing acts that occurred at different time points on the
21 same global background image.

22 Reference is now made to Figs. 6A and 6B that
23 represent two sample video frames illustrating two op-
24 tional display formats of diagnostic still images in a
25 soccer game pertaining to option d. above. It is
26 appreciated that various features of the invention which
27 are, for clarity, described in the contexts of separate
28 embodiments may also be provided in combination in a
29 single embodiment. Conversely, various features of the
30 invention which are, for brevity, described in the con-
31 text of a single embodiment may also be provided sepa-
32 rately or in any suitable subcombination.

33 In all embodiments shown and described hereina-
34 bove, either frames or individual fields may be manipu-
35 lated, according to alternative embodiments of the inven-
36 tion. Preferably, individual fields are manipulated.

1 It will be appreciated by persons skilled in
2 the art that the present invention is not limited to what
3 has been particularly shown and described hereinabove.
4 Rather, the scope of the present invention is defined
5 only by the claims that follow:

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CLAIMS

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4

5 1. A sports event video manipulating system for
6 manipulating a representation of a sports event, the
7 sports editor comprising:

8 a video field grabber operative to grab at
9 least one video field including a video image A/D con-
10 verter operative to digitize a grabbed video field;
11 an object tracker operative to track an object
12 through a plurality of successive video fields;
13 an object highlighter receiving input from the
14 object tracker and operative to highlight the tracked
15 object on each of the plurality of successive video
16 fields;

17 a D/A image converter operative to convert
18 output of the object highlighter into a video standard
19 format; and

20 a video display monitor.

21

22 2. A system according to claim 1 wherein said
23 video field grabber is replaced by a video frame grabber.

24

25 3. A system according to claim 1 and also compris-
26 ing a marking device allowing a user to indicate an
27 object of interest and providing an output indication of
28 the object of interest to the object tracker.

29

30 4. A system according to claim 1 and also compris-
31 ing a video editor operatively associated with the
32 video field grabber and with the video display monitor.

33

34 5. A system according to claim 1 wherein said
35 object tracker includes an object exiting monitor opera-
36 tive to monitor for exit of an object from at least one

1 video field.

2

3 6. A system according to claim 1 wherein said
4 object tracker is operative to track a plurality of
5 objects.

6

7 7. A system according to claim 6 wherein said
8 object tracker includes an occlusion predictor operative
9 to predict occlusion of at least one of the plurality of
10 tracked objects by at least one other object.

11

12 8. A system according to claim 6 wherein said
13 object tracker comprises a moving object identifier
14 operative to identify objects which are in motion at
15 least some of the time as the plurality of objects to be
16 tracked.

17

18 9. A system according to claim 8 wherein said
19 moving object identifier comprises a color analyzer
20 operative to distinguish at least one color characteriz-
21 ing objects at least sometimes in motion from at least
22 one background color characterizing stationary objects.

23

24

25 10. A system according to claim 1 wherein said
26 object tracker comprises actual location generating means
27 operative to generate and store an indication of an
28 actual location of a tracked object at an individual
29 time.

30

31 11. A system according to claim 1 wherein said
32 object tracker comprises field-of-view determining means
33 operative to provide an indication of the actual direc-
34 tion of a current field of view center.

35

36 12. A video imagery manipulating system for manipu-

1 lating video imagery comprising:
2 a video field grabber operative to grab at
3 least one video field;
4 an object tracker operative to track an object
5 through a plurality of successive video fields; and
6 an object highlighter receiving input from the
7 object tracker and operative to highlight the tracked
8 object on each of the plurality of successive video
9 fields.

10
11 13. A sports event video manipulating system for
12 manipulating a representation of a sports event, the
13 sports editor comprising:
14 a video field grabber operative to grab at
15 least one video field including a video image A/D con-
16 verter operative to digitize a grabbed video field; and
17 a field mosaic composer operative to receive a
18 plurality of digitized fields from the video field grab-
19 ber, representing a corresponding plurality of small
20 portions of an arena and to compose a mosaic of fields
21 representing a larger portion of the arena.

22
23 14. A system according to claim 13 and also com-
24 prising a field mosaic graphic output system operative
25 to provide a visually sensible representation of the
26 larger portion of the arena.

27
28 15. A system according to claim 14 wherein the
29 field mosaic graphic output system comprises:
30 a video display; and
31 a D/A converter operative to convert a digital
32 representation of the field mosaic to a video representa-
33 tion thereof.

34
35 16. A system according to claim 14 wherein the
36 field mosaic graphic output system comprises a computer

1 screen.

2
3 17. A system according to claim 14 wherein the
4 field mosaic graphic output system comprises a printer.
5 18. A system according to claim 13 wherein the
6 video field grabber comprises a video frame grabber
7 operative to grab at least one video frame and wherein
8 the A/D converter is operative to digitize a grabbed
9 video frame and wherein the field mosaic composer com-
10 prises a frame mosaic composer operative to receive a
11 plurality of digitized frames from the video frame grab-
12 ber and to compose therefrom a mosaic of frames.

13
14 19. A system according to claim 13 wherein the
15 plurality of small portions are viewed from a correspond-
16 ing plurality of distances, the differences between at
17 least some of the distances being comparable in size to
18 the distances themselves.

19
20 20. A system according to claim 13 wherein the
21 plurality of small portions are viewed from a single
22 location.

23
24 21. A sports event video manipulating system for
25 manipulating a representation of a sports event, the
26 sports editor comprising:

27 a video field grabber operative to grab a video
28 field sequence including a video image A/D converter
29 operative to digitize a grabbed video field; and
30 a motion-based foreground-background discrimi-
31 nator operative to differentiate foreground objects in
32 the video field sequence from background in the video
33 field sequence, at least partly on the basis of fore-
34 ground object motion.

35
36 22. A system according to claim 21 also comprising

1 a field mosaic composer operative to receive a sequence
2 of pluralities of digitized fields from the video field
3 grabber, each plurality of digitized fields representing
4 a corresponding plurality of small portions of an arena
5 and to compose a sequence of mosaics of fields, each
6 mosaic representing a larger portion of the arena,
7 and wherein said discriminator is operative to
8 differentiate foreground objects in the sequence of
9 mosaics.

10
11 23. A sports event video manipulating system for
12 manipulating a representation of a sports event, the
13 sports editor comprising:

14 a video field grabber operative to grab at
15 least one video field including a video image A/D con-
16 verter operative to digitize a grabbed video field; and
17 a foreground object shape foreground-background
18 discriminator operative to differentiate foreground
19 objects in the video field from background in the video
20 field, at least partly on the basis of foreground object
21 shape.

22
23 24. A sports event video manipulating system for
24 manipulating a representation of a sports event, the
25 sports editor comprising:

26 a video field grabber operative to grab at
27 least one video field including a video image A/D con-
28 verter operative to digitize a grabbed video field; and
29 a foreground object shape foreground-background
30 discriminator operative to differentiate a character-
31 bearing foreground object in the video field from back-
32 ground in the video field, at least partly on the basis
33 of character recognition.

34
35 25. A system according to claim 21 wherein said
36 discriminator differentiates foreground objects from

1 background objects at least partly on the basis of color.
2

3 26. A system according to claim 21 and also com-
4 prising a foreground object eliminator operative to
5 eliminate foreground objects and replace them with
6 adjacent background information.

7
8 27. A system according to claim 13 and also com-
9 prising a selected object replacer operative to identify
10 a selected object and to replace the selected object with
11 an icon in the mosaic.

12
13 28. A video indexing method comprising the steps
14 of:
15 providing a digital representation of a video
16 sequence featuring at least one object performing at
17 least one type of action; and
18 indexing the video sequence according to at
19 least one index.

20
21 29. A method according to claim 28 wherein the step
22 of indexing comprises the step of indexing according to
23 the identity of the object.

24
25 30. A method according to claim 28 wherein the step
26 of indexing comprises the step of indexing by action
27 type.

28
29 31. A method according to claim 29 wherein the
30 video sequence represents a sports event and the step of
31 indexing according to the identity of the object com-
32 prises the step of indexing according to the identity of
33 at least one player participating in at least a portion
34 of the sports event.

35
36 32. A method according to claim 31 wherein the step

1 of indexing comprises the step of indexing according to
2 the identity of a team participating in the sports event.

3

4 33. A method according to claim 30 wherein the step
5 of indexing comprises the step of indexing according to
6 the following group of action types:

7

offense; and

8

defense.

9

10 34. A video sorting method according to claim 28
11 wherein the step of indexing comprises the step of:
12 receiving at least one audio signal correspond-
13 ing to at least one frame of the video sequence; and
14 keyword spotting the audio signal for indices
15 in order to index the video sequence in accordance with
16 detected indices.

17

18 35. A method according to claim 34 wherein the step
19 of receiving comprises the step of receiving the audio
20 channel of the video sequence.

21

22 36. A method according to claim 34 wherein the step
23 of receiving comprises the step of receiving an audio
24 message from a user indicating an index.

25

26 37. A system according to claim 23 wherein the
27 foreground object shape discriminator comprises a ball
28 recognizer operative to recognize a ball.

29

30 38. A system according to claim 25 wherein said
31 discriminator comprises a team uniform recognizer opera-
32 tive to recognize member of a sports team by at least one
33 characteristic of his uniform.

34

35 39. A television sports event replay method com-
36 prising the steps of:

1 receiving a video sequence of at least a por-
2 tion of a sports event featuring at least one object in
3 action;
4 selecting at least one of the objects in ac-
5 tion;
6 tracking the selected objects through the video
7 sequence; and
8 broadcasting a replay of the video sequence on
9 television with the selected objects highlighted.

10
11 40. A television sports event replay method com-
12 prising the steps of:
13 receiving a video sequence of a sports event
14 segment, featuring at least one object in action, wherein
15 first and second portions of the segment takes place in
16 first and second portions of the playing field, respec-
17 tively and the second and first portions are not visible
18 in the video representation of the first and second
19 portions, respectively, of the sports event; and
20 broadcasting on television a representation of
21 the sports event segment in which the first and second
22 portions of the playing field constantly appear.

23
24 41. A system according to claim 1 wherein said
25 object highlighter is operative to draw the past trajec-
26 tory of at least one tracked object.

27
28 42. A sports event video manipulating method for
29 manipulating a representation of a sports event, the
30 method comprising:
31 grabbing and digitizing at least one video
32 field;
33 tracking an object through a plurality of
34 successive video fields;
35 receiving input from the object tracker and
36 highlighting the tracked object on each of the plurality

1 of successive video fields; and
2 converting output of the object highlighter
3 into a video standard format.

4
5 43. A video imagery manipulating method for manipu-
6 lating video imagery comprising:
7 grabbing at least one video field;
8 tracking an object through a plurality of
9 successive video fields; and
10 receiving input from the object tracker and
11 highlighting the tracked object on each of the plurality
12 of successive video fields.

13
14 44. A sports event video manipulating method for
15 manipulating a representation of a sports event, the
16 method comprising:
17 grabbing and digitizing at least one video
18 field; and
19 receiving a plurality of digitized fields from
20 the video field grabber, representing a corresponding
21 plurality of small portions of an arena and composing a
22 mosaic of fields representing a larger portion of the
23 arena.

24
25 45. A sports event video manipulating method for
26 manipulating a representation of a sports event, the
27 method comprising:
28 grabbing and digitizing a video field sequence;
29 and
30 differentiating foreground objects in the
31 video field sequence from background in the video field
32 sequence, at least partly on the basis of foreground
33 object motion.

34
35 46. A sports event video manipulating method for
36 manipulating a representation of a sports event, the

1 method comprising:
2 grabbing and digitizing at least one video
3 field; and
4 differentiating foreground objects in the video
5 field from background in the video field, at least partly
6 on the basis of foreground object shape.

7
8 47. A sports event video manipulating method for
9 manipulating a representation of a sports event, the
10 method comprising:
11 grabbing and digitizing at least one video
12 field; and
13 differentiating a character-bearing foreground
14 object in the video field from background in the video
15 field, at least partly on the basis of character recogni-
16 tion.

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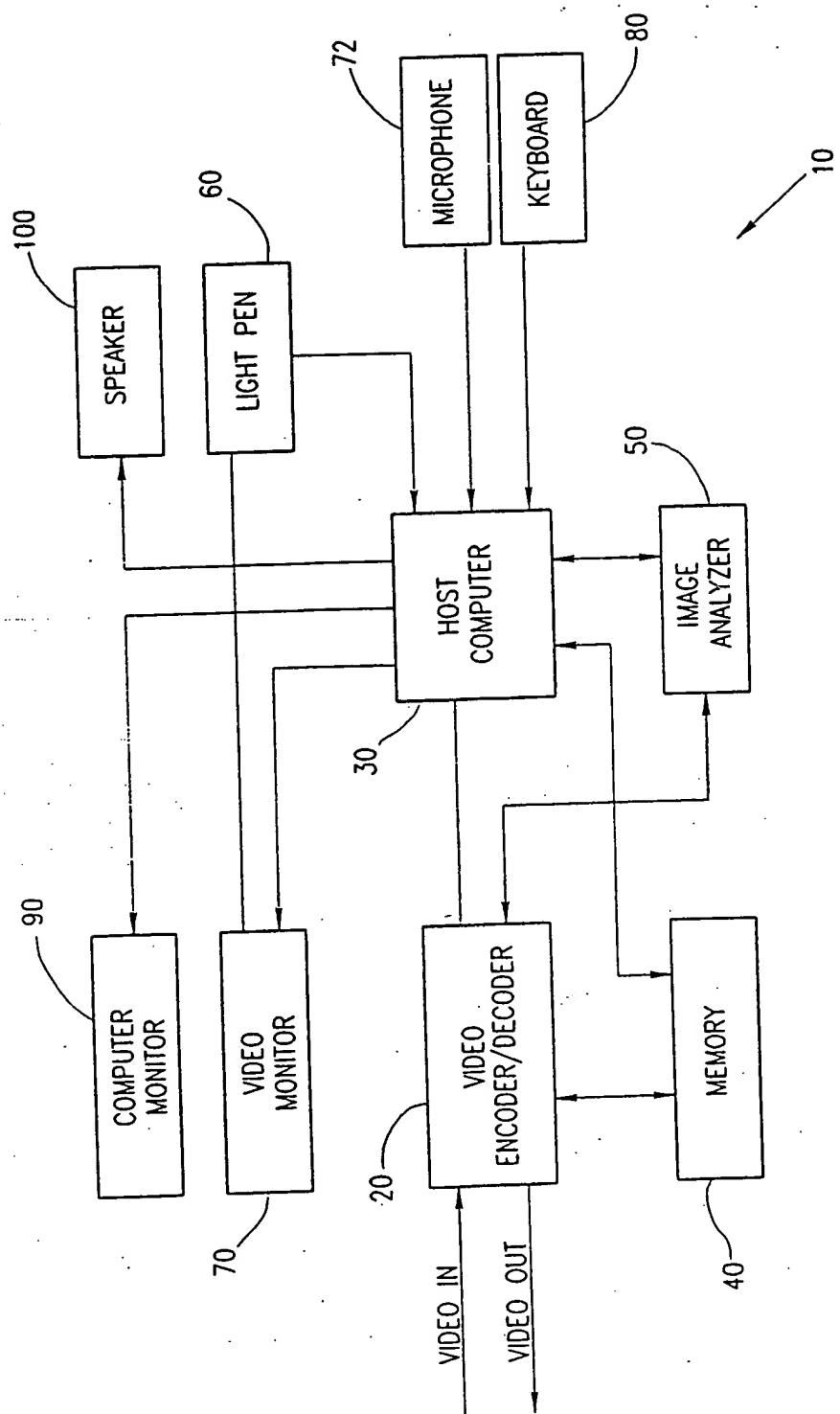


FIG. 1

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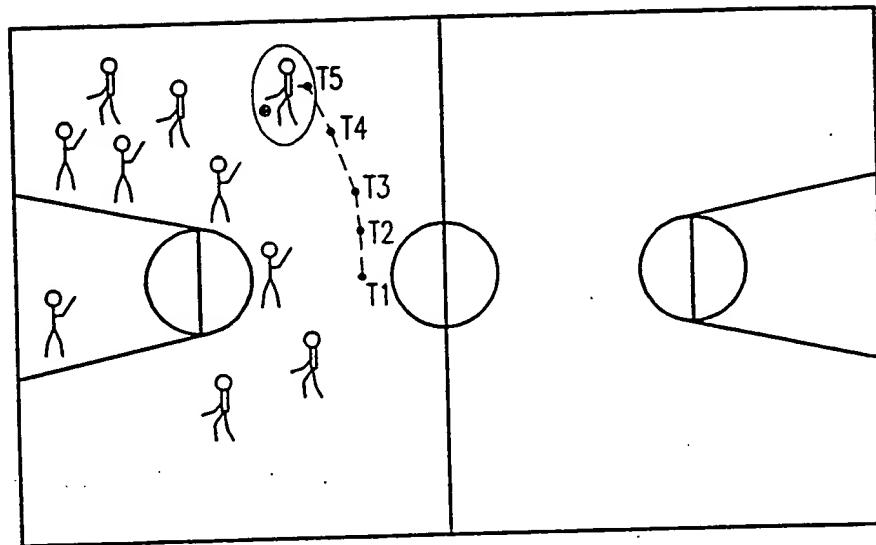


FIG.2

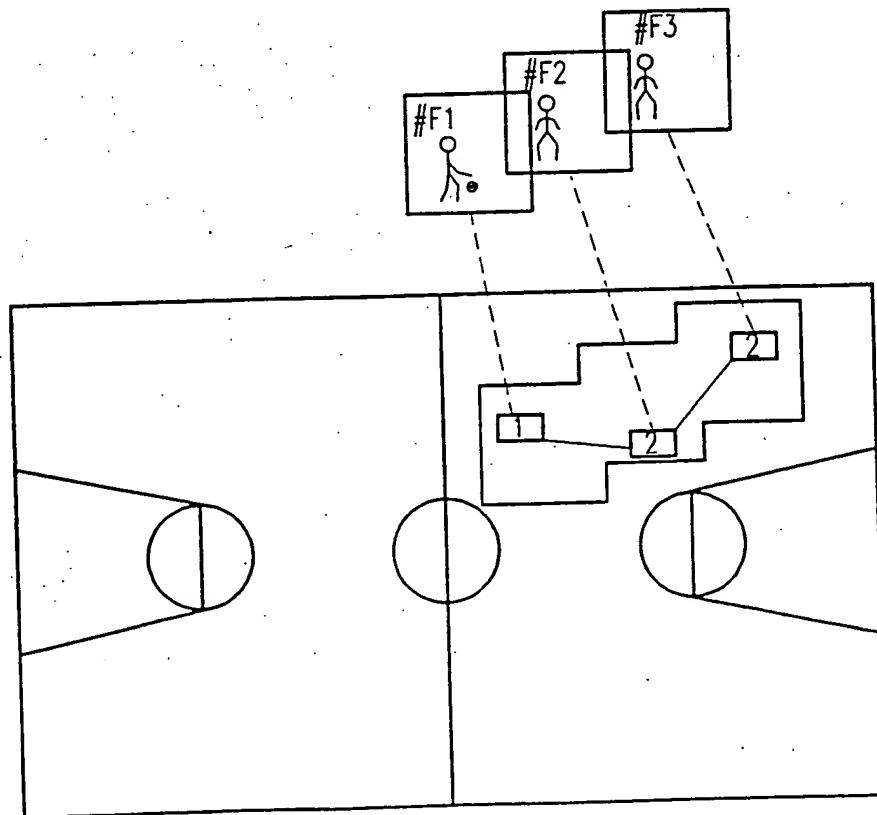


FIG.4

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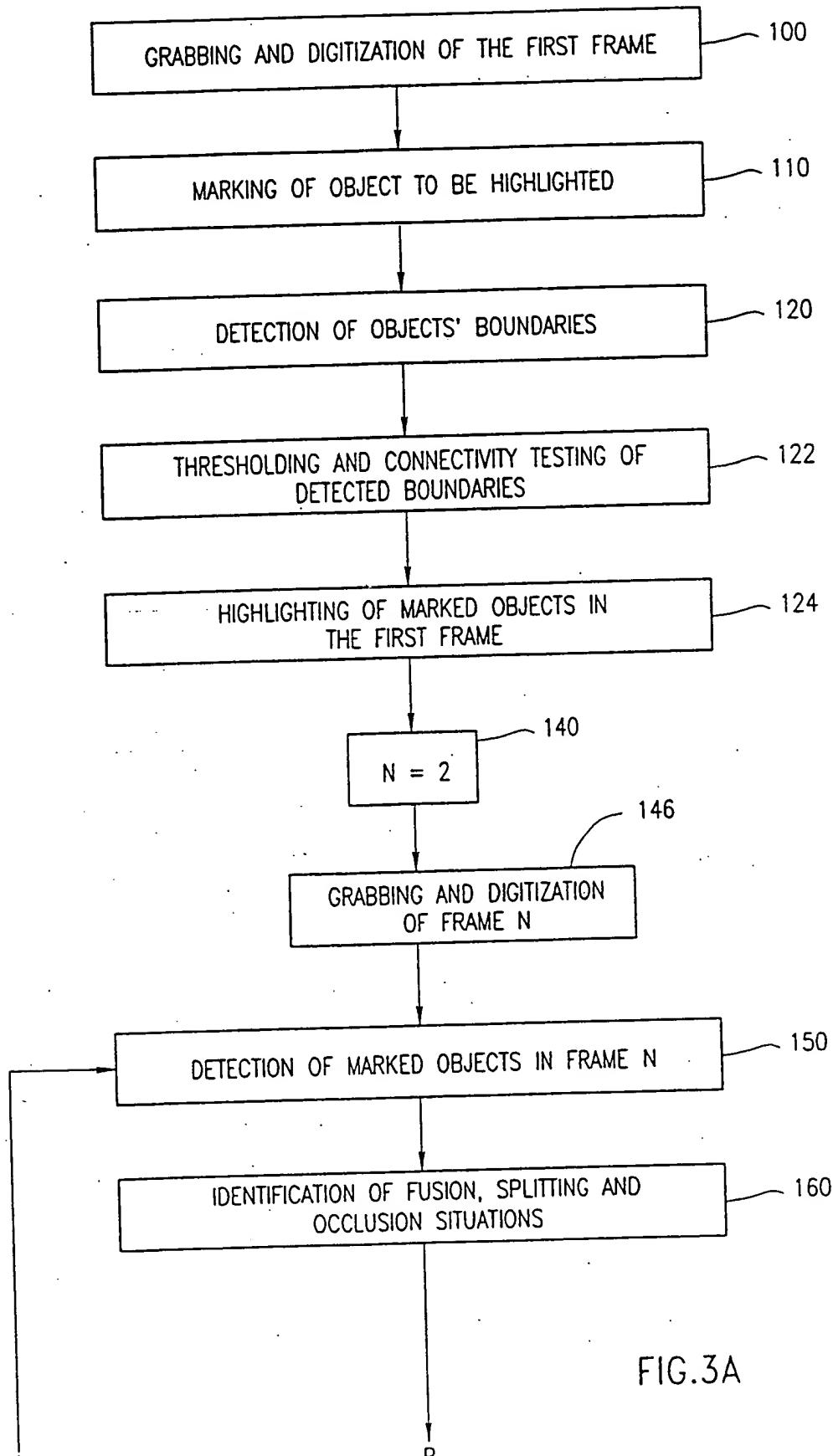


FIG.3A

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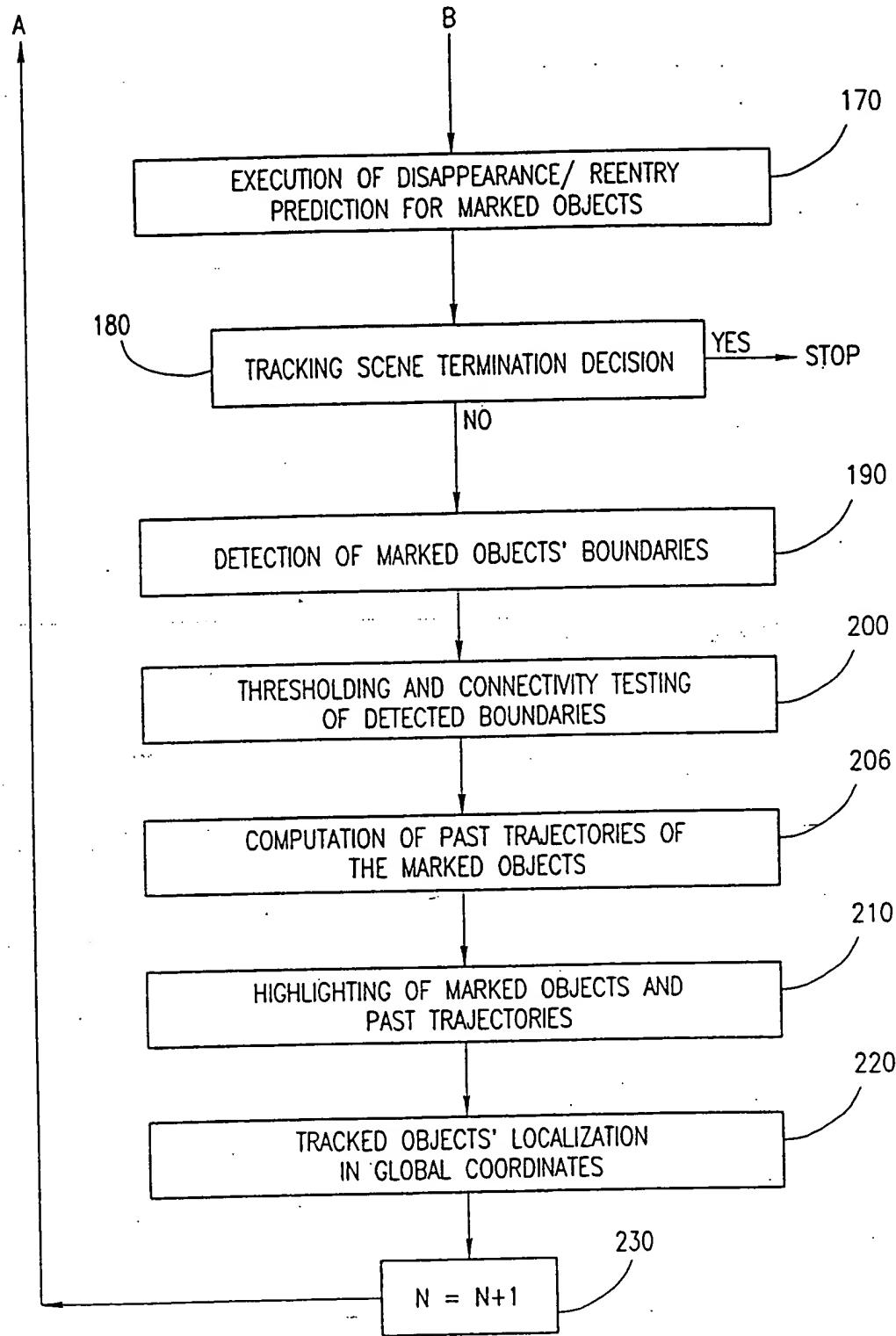


FIG.3B

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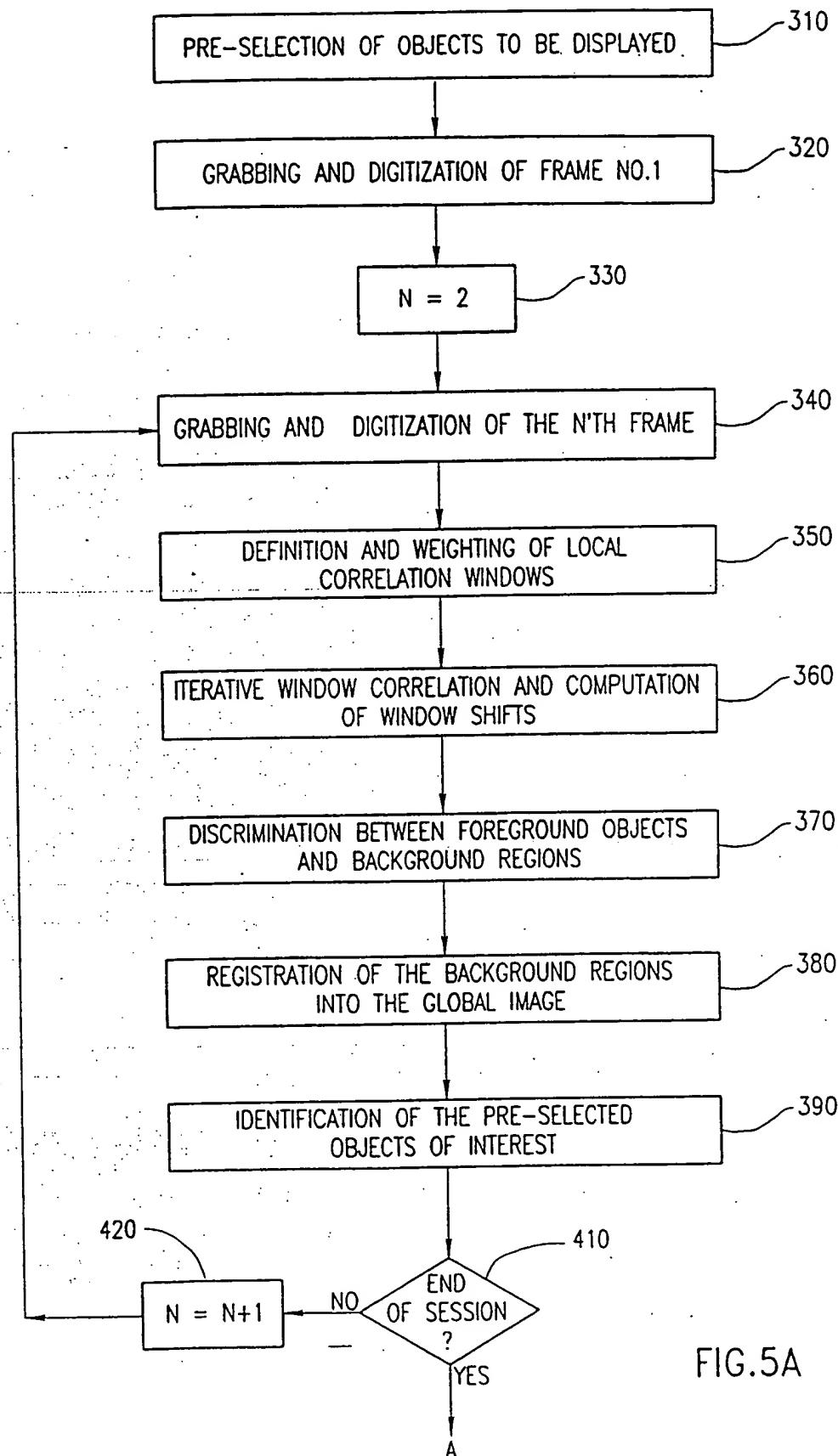


FIG.5A

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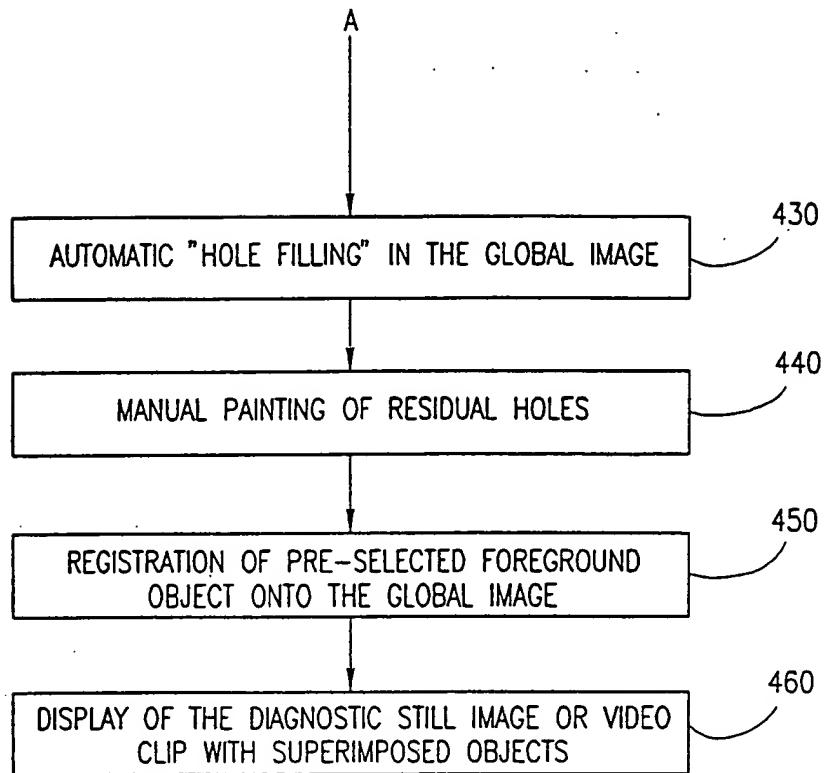


FIG.5B

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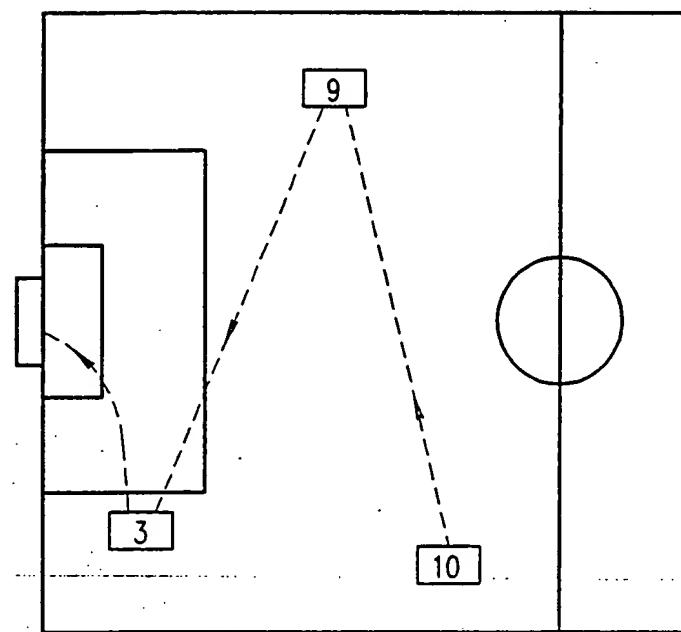


FIG.6A

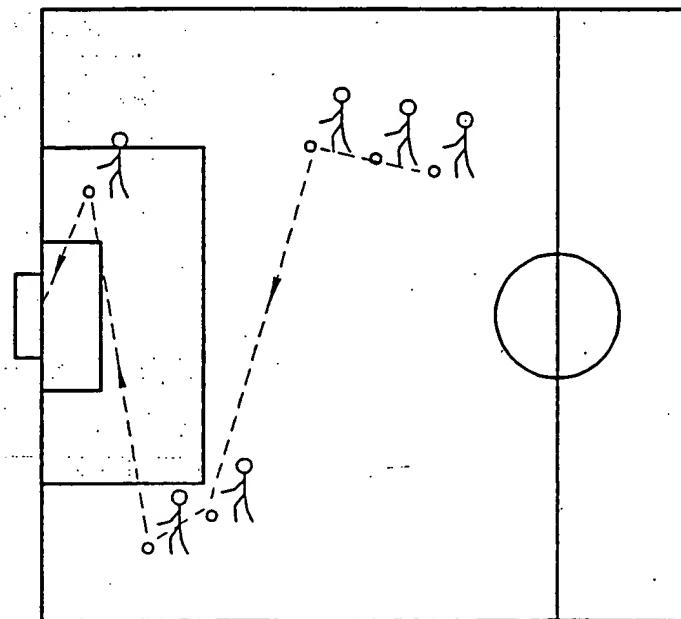


FIG.6B

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/11527

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04N 5/765, 3/04; G06F 9/00
US CL :348/157, 169

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 348/157, 169

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 5,206,929 (LANGFORD ET AL) 27 APRIL 1993, COL. 3, LINE 13; COL. 4, LINES 39-64; COL. 5, LINES 58-54; COL. 6, LINES 3-8.	1-12, 39-43
Y	US, A, 5,218,672 (MORGAN ET AL) 08 JUNE 1993, COL. 2, LINES 10-12, LINES 45-48; COL. 6, LINES 25-53; COL. 7, LINES 16-27, 55.	1-12, 39-43
Y	US, A, 5,012,334 (ETRA) 30 APRIL 1991, FIG. 1; COL. 2, LINES 28-52, 58.	1-12, 39-43
Y	US, A, 5,109,482 (BOHRMAN) 28 APRIL 1992, FIGS. 1-2, 11; COL. 1, LINES 1-2; COL. 2, LINES 27-28, 58, 53-55; COL. 3, LINES 64-66.	1-12, 39-43

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
A document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
E earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
O document referring to an oral disclosure, use, exhibition or other means		
P document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search	Date of mailing of the International search report
24 JANUARY 1995	17 FEB 1995

Name and mailing address of the ISA/US
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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US94/11527

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.: 1-12 and 39-43
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

The additional search fees were accompanied by the applicant's protest.
 No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US94/11527

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

Group I. Claims 1-12 and 39-43, drawn to a video camera tracking system wherein an object is being tracked through a video sequence, classified in Class 348, subclass 169.

Group II. Claims 13-20, 27 and 44, drawn to an image signal processing system for changing the size of the image, classified in Class 348, subclass 580.

Group III. Claims 21-26, 37-38 and 45-47, drawn to an image signal processing system with foreground-background detection, classified in Class 348, subclass 586.

Group IV. Claims 28-36, drawn to an image signal processing system using video indexing, classified in Class 348, subclass 571.

The groups of inventions do not have in common the same special technical features since they are directed to four distinctly different inventions which employ different system arrangements.